COST OF OPERATING REFRIGERATED TRUCKS FOR HAULING FRESH FRUITS AND VEGETABLES

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ABSTRACT

This report uses synthetic cost analysis to develop per mile costs for operating refrigerated trucks hauling fresh fruits and vegetables. The effects of multiple pickups and deliveries and loaded backhaul on costs are examined. The relationship between product density and rates is also examined.

In general, the cost per mile decreases as the length of trip is increased. Loaded backhaul and multiple pickups and deliveries increase the per mile cost considerably for shorter trips but only slightly for the longer trips. The primary factor determining the level of cost per mile is the degree of driver-truck utilization. Product density has considerable effect on the rates that must be charged to cover a trucker's cost.

Key words: Transportation, fresh fruits and vegetables, trucking costs, rates, backhaul.

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By Patrick P. Boles 1/

INTRODUCTION

Shippers of fresh fruits and vegetables are becoming more dependent on motor trucks for their transportation needs. In 1961, trucks accounted for 62.3 percent of all fresh fruit and vegetable unloads (carlot equivalents) at 41 cities as reported by USDA's Agricultural Marketing Service (8). 2/ By 1970, trucks accounted for 69.5 percent and in 1975 their share was 83.5 percent.

As truckers have increased their share of the fresh fruit and vegetable shipments, there have been reports of truck shortages in some shipping areas during certain periods of the year. If, in fact, serious shortages of trucks exist for more than brief periods, it must be concluded that rates are not high enough to attract the number of trucks needed or wanted to a particular area. Since fresh fruits and vegetables are exempt from economic regulation for interstate shipments by truck, it is logical to assume that rates charged for interstate shipments are subject to the supply of trucks available to haul these products and the demand for their services. However, the structure of a trucker's costs is important in determining the rates he must charge to cover his costs and survive in the business.

The purpose of this study is to analyze the costs of operating refrigerated trucks that haul fresh fruits and vegetables for various trip lengths, operating situations, and levels of driver-truck utilization. Such information can be helpful to shippers and truckers in evaluating the adequacy of specific trucking rates to maintain hauling capacities for fresh fruits and vegetables. A shipper or trucker owning his own trucks could use his own cost components, time estimates, and operating procedures in the analytical framework developed and make estimates of his own costs.

SOURCE AND NATURE OF DATA

The cost data in this report were developed from information obtained in 1976 from nine trucking firms based in California, Florida, and Texas that operated refrigerated trailers. Most cost information supplied was for 1975 and 1976.

Firms differed considerably in size and type of operation. Some firms hauled only fresh fruits and vegetables that were exempt from economic regulation by the Interstate Commerce Commission (ICC). Some firms had operating rights to transport certain regulated products interstate and other firms had authorities to haul products under intrastate regulation. In all cases, the firms hauled fresh fruits and vegetables in interstate movements.

1/ Agricultural economist, National Economic Analysis Division, Economic Research Service.

2/ Underscored numbers in parentheses refer to items in references at the end of this report.

All firms reported using heavy-duty diesel truck-tractors and insulated aluminum trailers with refrigerated units. Most trailers were 42 feet long. This type of trailer is suited to haul many types of products, including regulated perishable products such as meats.

The firms interviewed reported having annual truck mileages ranging from 80,000 to 180,000 miles per truck. The higher annual mileages were reported only by firms that made long trips between California and the East Coast. Only one firm had a substantial number of trips that were less than 500 miles.

Seasonality in shipments was not a problem for these firms. Florida truckers hauled products from Georgia and the Carolinas when shipments from Florida were not available. Texas truckers hauled products from the Rio Grande Valley when available, and west Texas during the summer months. California truckers hauled products from the different producing areas of the State to keep their vehicles busy.

The costs of operations developed in this report do not necessarily represent the "average" costs for all truckers hauling fresh fruits and vegetables. Assumptions concerning operations were developed from interviews with owners or managers of the nine firms or from other research publications (2, 5, 7). Most cost factors were derived from the cost components reported by the nine firms. In the case of the cost of tractors and trailers, averages of prices paid for 1976 equipment were used.

Owner-operators (one-truck firms) are reported to be prevalent in the hauling of fresh fruits and vegetables and other ICC exempt commodities (10, p. 19). While such firms are probably important in the transportation of fresh fruits and vegetables, they are difficult to locate for the collection of cost data because of the away-from-home nature of their operations. No owner-operators were interviewed in the survey and an analysis of one-truck operations was not made.

COST COMPONENTS

Since firms reported their cost items in various forms, the first step was to develop comparable cost components. Averages of the various cost components were then developed and used as inputs in the synthetic analysis of trucking costs.

Interviews with the nine trucking firms indicated that they varied considerably in the number of trucks operated and the type of operation. Casavant and Nelson, in studies of livestock and grain trucking, indicated only limited economies are achieved as firm size increases from 1 tractor and trailer to 3 tractors and 4 trailers, and even lesser economies are achieved from increases in size up to 12 tractors and 14 trailers (3, 4). Anderson and Budt, in a study of Nebraska meat trucking, analyzed firm sizes ranging from 10 to 300 trucks. They found that the size of meat trucking firms had relatively little effect on per unit cost. In 1973, the cost of shipping meat 1,500 miles was $3.54 per hundredweight by a 10-truck firm at 100 percent of plant utilization compared with $3.33 per hundredweight by a 300-truck firm at 100 percent of

plant utilization (1, pp. 12-14). With these studies in mind, it was determined that an analysis of all the firm sizes and types of operations reported by the nine firms interviewed would not supply enough additional information to justify the time and expense of such an undertaking. Therefore, the analysis is limited to one firm size and type of operation. The model firms for this analysis each operate 10 tractors and trailers. In addition, the model firms each own a building housing an office and shop, a parking lot adequate for several cars and trucks, office and shop equipment, and a pickup truck.

While no analysis of owner-operators (one-truck firms) was made, the principle differences in their cost and that of the 10-truck model firms analyzed are in (1) substitution of additional purchased maintenance and repairs by owner-operators, (2) purchase of certain services from truck brokers and bookkeeping firms by owner-operators, and (3) no direct driver wage cost by owner-operators. Otherwise, the structure of their cost should be about the same.

Fixed Costs

In this report fixed cost items are assumed to be most of those expenditures that a firm must make at a relatively constant rate regardless of the number of miles each truck is driven in a year.

Interest and depreciation was the largest individual fixed cost item. It was assumed that all of the physical property of the firm would be financed by borrowed funds at a 10-percent rate of interest. Interest charges are added for all items but depreciation for tractors and trailers is not included. Depreciation for tractors and trailers has attributes of both fixed and variable cost and it is handled as a separate cost category. Interest charges for the 10 tractors and trailers are $35,400 per year (table 1). Interest and depreciation on other items are $8,378 per year, for a total of $43,778 for this cost component (table 2).

Table 1--Estimated interest cost for 10 tractors and refrigerated trailers, 1976

Item	Original cost 1/	Salvage value	Interest per year 2/
	Dollars	Percent	Dollars
Tractors	380,000	20	22,800
Trailers	210,000	20	12,600
Total	590,000	--	35,400

1/ Based on the average prices for 1976 equipment purchases reported by nine firms interviewed.

2/ Assumes an interest rate of 10 percent applied to the midlife average value per tractor and trailer.

Table 2--Estimated depreciation and interest cost for land, building, and non-revenue equipment, 1976 1/

Item	Investment cost	Years of depreciation	Salvage value	Yearly depreciation	Yearly interest	Depreciation and interest
	Dollars	Years	Percent	---- Dollars ----		
Shop and office	60,000	25	--	2,400	3,000	5,400
Land	5,000	--	--	--	500	500
Office equipment ...	5,000	10	10	450	275	725
Shop equipment	4,500	10	10	405	248	653
Pickup truck	5,000	5	20	800	300	1,100
Total	79,500	--	--	4,055	4,323	8,378

1/ Nonrevenue equipment refers to all equipment except truck-tractors and refrigerated trailers.

The second largest item of fixed cost is office salaries and benefits amounting to $38,200 per year. This cost amounting to $3,820 per truck operated would be handled differently by owner-operators. They would be expected to incur more brokerage fees than the larger firms and in many cases would require the services of bookkeeping firms.

Insurance on all items would be $33,300 per year. Of this amount, $31,800 or $3,180 per vehicle is for liability, collision, and cargo insurance on the tractors and trailers. Insurance rates on tractors and trailers for a specific firm may be higher or lower depending upon the safety and cargo loss claims of the firm. However, this amount is equal to the average insurance cost per tractor and trailer reported by the nine firms in the survey. The remaining $1,500 is for insurance on the building, other equipment, the pickup truck, and office employees. This figure does not include the cost of various types of insurance for drivers and shop employees.

Other fixed cost items amount to $24,000 per year. This includes $11,100 for general office expenses such as office supplies, standard telephone charges, legal and audit, and miscellaneous (table 3). Licenses for tractors and trailers and the pickup truck are $9,800 per year. Taxes are $3,100 and include Federal Use Tax on the tractors and trailers, property tax on the real estate, and personal property tax on some equipment. The total annual fixed costs per firm are estimated at $139,278 or $13,928 per vehicle (table 4).

Vehicle Depreciation

Vehicle depreciation is regarded as a fixed cost item in many analyses of truck costs (1, 3, 4, 5, 7). In other studies, vehicle depreciation is considered to be a function of utilization alone or a combination of utilization and age of the equipment (2, 10, p. 25). Firms interviewed for this study had considerable variation in the yearly level of vehicle utilization (see page 2). These firms also indicated that the lifetime mileage for tractors averaged about 650,000 miles and for refrigerated trailers, about 850,000 miles. This

Table 3--Estimated general office expenses, 1976

Item	Cost per year
	Dollars
Telephone (standard charge)	300
Office supplies	2,300
Advertising	800
Legal and audit	2,900
Utilities	800
Dues and charities	400
Travel (management)	900
Miscellaneous	2,700
Total	11,100

Table 4--Estimated annual fixed costs, 1976

Item	Total for year	Average per truck
	Dollars	
Interest and depreciation 1/	43,778	4,378
Office salaries and fringe benefits	38,200	3,820
Insurance	33,300	3,330
General office expenses	11,100	1,110
Licenses 2/	9,800	980
Taxes	3,100	310
Total	139,278	13,928

1/ Does not include depreciation for the truck-tractors and refrigerated trailers.

2/ Assumes that license cost is prorated among the States in which the firm operates.

suggests that using a standard yearly depreciation for all types of operations regardless of yearly mileage driven per truck would either overstate or understate the true depreciation cost for some operations. Obviously, most firms depreciate their vehicles over a standard number of years for income tax purposes. However, costs as reported to the Internal Revenue Service are for the firm and do not necessarily reflect the true opportunity costs of doing business of certain types.

In order for vehicle depreciation to be applicable to operations having different levels of vehicle utilization, it is developed as a separate cost category. A tractor and refrigerated trailer are estimated to cost $59,000 and each component is expected to have a 20-percent salvage value at the end of its useful life to the firm. It is assumed that tractors and trailers are

obsolete for use by the firm after a 10-year period. These assumptions result in an annual depreciation for a tractor of $3,040 for the first 65,000 miles driven each year, plus $.047 for each additional mile. Annual depreciation for a refrigerated trailer is $1,680 for the first 85,000 miles driven each year, plus $.02 for each additional mile.

Driver Costs

All firms in the survey reported paying drivers a percentage of the revenue or a per mile fee. These types of compensation are often regarded as variable costs. However, some items of driver compensation such as Social Security payments and unemployment compensation payments are variable up to a point and then become fixed. There are also operating situations where the number of yearly miles driven would result in a very low salary for drivers paid on a standard per mile basis. Therefore, driver cost is considered a separate cost item in this report.

Estimated driver compensation is 12 cents per mile for one driver per truck and 14 cents per mile for a two-driver team. These estimates are approximately equal to the driver cost per mile reported by the firms in the survey, including those that compensated their drivers with a share of the revenue. It is assumed that, in order to keep competent drivers, the model firms would pay a minimum yearly salary of $9,000 for each driver making trips where the total yearly mileage would not yield that amount of wages based on the standard mileage rate. Included in total driver cost would be fringe benefits, which include the employer's contribution to Social Security, unemployment compensation insurance, workmen's compensation insurance, health and welfare plan, and a living allowance for duty away from the home station (table 5). No separate provision is made for paid holidays, sick leave, or vacations for the drivers since drivers are compensated on a mileage rather than a time basis.

Table 5--Estimated driver compensation, 1976

Item	Cost
Base pay (one driver) 1/	12 cents per mile
Base pay (two drivers) 2/	14 cents per mile
Social Security	5.85% of first $15,300 per driver
Unemployment compensation insurance	2.6% of first $4,200 per driver
Workmen's compensation insurance	7.96% of total salary
Health and welfare plan	2.4% of total salary
Living allowance	$10 a day on the road per driver

1/ For yearly mileages less than 75,000, minimum base pay would be $9,000 per year.

2/ For yearly mileages less than 128,171, minimum base pay would be $9,000 per year for each driver.

Direct Variable Costs

Direct variable costs include all those items that are associated only with vehicle trips. All items of direct variable costs are estimated at 22.5 cents per mile (table 6).

Table 6--Estimated direct variable cost of operating a refrigerated truck, 1976

Item	Cost per mile
	Cents
Fuel	11.82
Tires	2.01
Maintenance	6.25
Telephone (long distance)	.58
Miscellaneous 1/	1.84
Total	22.5

1/ No provision is made for third structure taxes, such as axle-mile tax, since they are paid in only a limited number of States.

The single most expensive item of direct variable costs was fuel at 11.82 cents per mile. This is based on an average fuel consumption of 4.5 miles per gallon and an average cost of 52 cents per gallon as reported by the nine firms in the survey.

Maintenance cost for a tractor and trailer is estimated at 6.25 cents per mile and represents the average reported by the nine firms. It includes all shop costs of wages and benefits for shop personnel, parts, grease and oil, and shop supplies. It also includes all maintenance performed outside the shop, such as repairs on the refrigerated units.

Tire cost for a tractor and trailer is estimated at 2.01 cents per vehicle mile. This is an average for the nine firms whose tire cost ranged from 1.5 to 2.57 cents per vehicle mile. Long-distance telephone calls are estimated at .58 cents per vehicle mile. These are calls made by drivers to the home office and calls by both the office and drivers to shippers, receivers, and brokers.

Miscellaneous charges are estimated at 1.84 cents per mile. These include road tolls, unloading fees, 3/ icing fees, cleaning the trailers away from home stations, and fuel for the refrigeration unit.

3/ Unloading fees were reported to be from $40 to $50 per load; however, the amount per mile included here is based on the average paid by the nine firms and includes palletized loads which do not require an unloading fee. A firm could have considerably higher miscellaneous charges depending upon its operating situation.

PER MILE COST

Interviews with the nine firms indicated that there are many factors associated with their operations that can affect the level of cost. For example, the truckers reported a wide variation in their average trip lengths and total annual miles per vehicle. Most indicated that multiple pickups and deliveries are prevalent in fresh fruit and vegetable trucking. Miklius and DeLoach, in a study of interstate trucking of exempt products for California, found that 74 percent of truck shipments involved more than one pickup and one delivery (6, p. 10). Also, delays of 1 or more days to obtain a loaded backhaul are quite common for some truckers. All of these factors are closely related to vehicle utilization and, in turn, affect the level of cost per vehicle mile.

Costs per mile were developed for two basic types of situations. One was described by truck trips of specific distances and operational conditions and the other by various levels of truck utilization under a specific operational condition.

To limit the cost analysis to a feasible scale, several assumptions were made. The number of operational situations were limited to 12 which were specified by the number of pickups, deliveries, and delays for loaded backhaul (table 7). Trips were limited to 10, ranging from 100 to 3,000 miles one way. Total trip mileages were derived by the use of the information in table 8.

Table 7--Definition of 12 operational situations

Operating situation	Initial haul		Backhaul		Delay for loaded backhaul
	Pickups	Deliveries	Pickups	Deliveries	
	Number				Days
1	1	1	0	0	0
2	1	1	1	1	0
3	1	1	1	1	1
4	1	1	1	1	2
5	2	2	0	0	0
6	2	2	2	2	0
7	2	2	2	2	1
8	2	2	2	2	2
9	4	4	0	0	0
10	4	4	4	4	0
11	4	4	4	4	1
12	4	4	4	4	2

Time requirements for specific trips can be very important in determining the per mile cost. Only truck checkout is standard regardless of trip length or operating situation. Deadheading, loading, unloading, and waiting time depend on the number of pickups and deliveries. Time spent driving and on meal stops

and rest stops depends on trip length and the number of drivers. 4/ Layover is determined by delays in obtaining a loaded backhaul. Table 9 shows the author's estimate of time required for various activities.

Table 8--Information used to develop trip mileages for various operational situations

Operational situation 1/	Pickup and delivery miles	Line haul		Total round trip miles 2/
		Fully loaded miles	Empty miles	
1	25	n	n	2n + 25
2	50	2n	0	2n + 50
3	50	2n	0	2n + 50
4	50	2n	0	2n + 50
5	75	n	n	2n + 75
6	150	2n	0	2n + 150
7	150	2n	0	2n + 150
8	150	2n	0	2n + 150
9	175	n	n	2n + 175
10	350	2n	0	2n + 350
11	350	2n	0	2n + 350
12	350	2n	0	2n + 350

1/ See table 7.

2/ Assumes a 25-mile empty movement from home office or point of last delivery to first pickup point, and 25-mile segments between individual pickup and delivery points.

n = one-way trip distance from point of last pickup to point of first delivery.

It was assumed that drivers would have 2 weeks off each year for vacation and 1 day off each week whenever possible. Minor maintenance, such as tire and oil changes, would be done on the idle day each week, and major overhauls, if necessary, would be done during the 2-week idle period each year. It was also assumed that a driver or two-man driving team would be assigned to one tractor and trailer throughout the year.

Hours away from home for a specific trip length were used to determine the number of days required for the trip. DOT safety regulations, in some cases, added 1 or 2 days to the longer trips or limited the number of shorter trips

4/ Motor carrier safety regulations by the U.S. Department of Transportation (DOT) set the number of hours that a driver can be on duty (9). A driver may be on duty 60 hours in any continuous 7-day period or 70 hours in any continuous 8-day period depending upon the trucker's operation. On-duty time includes numerous tasks a driver may perform in conjunction with his driving, such as inspecting equipment and supervising loading and unloading. These regulations limit the number of trips that a driver or a two-driver team can make in 1 year.

that could be driven in a year. These figures were used to develop schedules for trucks specializing in a given operational situation and trip length which, in turn, gave the number of trips a truck would make in a year (table 10). The number of trips per year times the total trip mileage gave the feasible total annual mileages shown in table 11. The fully loaded miles per trip times the number of trips gave the feasible fully loaded mileages per year shown in table 12.

Table 9--Estimated time required to operate a refrigerated truck

Item	Time required
	Hours
Truck checkout	.25 per round trip
Loading and waiting time	2.0 per pickup
Driving time 1/	.022 per mile
Rest stops 2/	8.0 per stop
Meal stops	.5-16.0
Unloading and waiting time	2.0-16.0
Layover 3/	0-48.0

1/ Driving time includes time spent driving to pick up initial load and to make deliveries. Each empty and partial load segment is assumed to be 25 miles long and to require 33 minutes to make. When there are 4 pickups and 4 deliveries there would be 2.2 hours deadhead time for pickups and 1.65 hours for deliveries.

2/ Rest stops apply only to trucks having one driver. Federal safety regulations require 8 hours rest after 10 hours continuous driving or 15 hours on duty.

3/ Layover refers to time spent waiting for a loaded backhaul.

The general trend was for total annual mileage to increase as the trip length increased. This did not hold true in all cases because of scheduling to meet safety rules. For example, the largest total annual mileage was for the 2,500-mile rather than the 3,000-mile trip (table 11). Total annual mileage per truck ranged from 21,750 to 246,225 miles.

Table 13 shows the cost per mile for all miles driven for the 10 different trip lengths and 12 operating situations. In most cases, the cost per mile goes down as the length of trip increases. Exceptions are the result of scheduling problems that cause a lower total annual mileage than a shorter trip length, thus increasing the per mile cost.

Within trip length categories, per mile cost increases significantly when loaded backhaul is added for most of the lower trip distances but increases only slightly for many the longer trip distances. This results from the extra time required for a loaded backhaul making up a much larger part of the overall time requirements for shorter trips than for longer trips. Therefore, the trucker can afford to offer a much more attractive backhaul rate for longer trips than shorter trips if the market for truck services so dictates.

Table 10--Estimated number of trips per year for a refrigerated truck hauling fresh fruits and vegetables 1/

Operational situation	One-way distance									
	100	200	300	400	500	1000	1500**	2000**	2500**	3000**
	Miles									
1	250	220	150	131	100	60	77	58	49	38
2	210	131	131	100	87	55	58	50	43	38
3	131	100	87	82	60	50	50	43	38	35
4	87	77	70	70	50	43	43	38	35	31
5	210	150	129	100	87	50	69	55	45	38
6	125	105	87	80	71	46	56	46	38	34
7	100	87	70	70	60	43	50	43	35	34
8	77	60	50	50	50	38	43	38	31	31
9	116	100	87	79	70	46	56	46	39	34
10	60	60	56	50	43	43*	40	35	31	28
11	60	50	56	50	43	43*	40	35	31	28
12	50	43	50	43	38	38*	38	35	31	28

1/ See tables 7, 8, and 9.
* Indicates two-driver teams on these three trips.
** Indicates two-driver teams on all trips in these mileage groups.

Table 11--Estimated total annual mileages for a refrigerated truck hauling fresh fruits and vegetables 1/

Operational situation	One-way distances									
	100	200	300	400	500	1000	1500	2000	2500	3000
	1,000 miles									
1	56.3	93.5	93.8	108.1	102.5	121.5	232.9	233.5	246.2	229.0
2	52.5	59.0	85.2	85.0	91.4	112.8	176.9	202.5	217.2	229.9
3	32.8	45.0	56.5	69.7	63.0	102.5	152.5	174.2	191.9	211.8
4	21.8	34.7	45.5	59.5	52.5	88.2	131.2	153.9	176.8	187.6
5	57.8	71.3	87.1	87.5	93.5	103.8	212.2	224.1	228.4	230.9
6	43.8	57.8	65.3	76.0	81.7	98.9	176.4	190.0	195.7	209.1
7	35.0	47.9	52.5	66.5	69.0	92.5	157.5	178.5	180.3	209.1
8	27.0	33.0	37.5	47.5	57.5	81.7	135.5	157.7	159.7	190.7
9	43.5	57.5	67.4	77.0	82.3	100.1	177.8	192.1	201.8	210.0
10	33.0	45.0	53.2	57.5	58.1	101.1	134.0	152.3	165.9	177.8
11	33.0	37.5	53.2	57.5	58.1	101.1	134.0	152.3	165.9	177.8
12	27.5	32.3	47.5	49.5	51.3	89.3	127.3	152.3	165.9	177.8

1/ See tables 7, 8, and 10.

Table 12--Estimated fully loaded annual mileages for a refrigerated truck 1/

Operational situation	One-way distance									
	100	200	300	400	500	1000	1500	2000	2500	3000
	1,000 miles									
1	25.0	44.0	45.0	52.4	50.0	60.0	115.5	116.0	122.5	114.0
2	42.0	52.4	78.6	80.0	87.0	110.0	174.0	200.0	215.0	228.0
3	26.2	40.0	52.2	65.6	60.0	100.0	150.0	172.0	190.0	210.0
4	17.4	30.8	42.0	56.0	50.0	86.0	129.0	152.0	175.0	186.0
5	21.0	30.0	38.7	40.0	43.5	50.0	103.5	110.0	112.5	114.0
6	25.0	42.0	52.2	64.0	71.0	92.0	168.0	184.0	190.0	204.0
7	20.0	34.8	42.0	56.0	60.0	86.0	150.0	172.0	175.0	204.4
8	15.4	24.0	30.0	40.0	50.0	76.0	129.0	152.0	155.0	186.0
9	11.6	20.0	26.1	31.6	38.5	46.0	84.0	92.0	97.5	102.0
10	12.0	24.0	33.6	40.0	43.0	86.0	120.0	140.0	155.0	168.0
11	12.0	20.0	33.6	40.0	43.0	86.0	120.0	140.0	155.0	168.0
12	10.0	17.2	30.0	34.4	38.0	76.0	114.0	140.0	155.0	168.0

1/ See tables 7, 8, and 10.

Table 13--Cost of operating a refrigerated truck hauling fresh fruits and vegetables per vehicle mile, 1976

Operational situation 1/	One-way trip distance (miles)									
	100	200	300	400	500	1000	1500	2000	2500	3000
	Dollars per vehicle mile									
1	.788	.605	.613	.586	.598	.566	.544	.540	.535	.543
2	.821	.765	.626	.626	.604	.580	.568	.544	.547	.546
3	1.197	.918	.788	.683	.736	.598	.586	.571	.560	.551
4	1.687	1.134	.929	.763	.838	.625	.608	.586	.571	.563
5	.767	.680	.622	.626	.610	.591	.548	.542	.540	.542
6	.951	.767	.713	.649	.638	.597	.567	.558	.558	.554
7	1.142	.890	.835	.707	.694	.611	.582	.568	.568	.554
8	1.419	1.182	1.070	.892	.785	.635	.604	.582	.582	.563
9	.959	.785	.698	.646	.620	.599	.565	.557	.552	.550
10	1.182	.941	.826	.776	.780	.699	.597	.579	.570	.562
11	1.182	1.084	.826	.776	.780	.699	.602	.584	.574	.565
12	1.378	1.223	.903	.867	.853	.753	.615	.588	.577	.569

1/ See table 7 for definitions.

The number of pickups, deliveries, and delays to obtain a loaded backhaul have an effect on per mile cost because these increase the time required to make a trip. In general, delays to obtain a loaded backhaul increase cost more than do additional pickups and deliveries. The most expensive cost per mile was for the round trip having a 100-mile, one-way distance with two pickups, two

deliveries, and a 2-day delay to obtain a loaded backhaul. The least expensive cost per mile was for the round trip having the 2,500-mile, one-way distance with one pickup, one delivery, and no loaded backhaul.

Truckers interviewed indicated that rates are established for distances between originating production areas and destination cities rather than actual mileage. The cost per mile for total miles traveled gives truckers a picture of the cost relationships between trip distances and operational situations, and when these costs are applied to total trip mileages, shows the total cost of various trips. However, it does not show the cost relationships between various one-way distances and operational situations when the vehicle is fully loaded from origin to destination. Table 14 shows the cost per fully loaded mile.

Table 14--Cost of operating a refrigerated truck hauling fresh fruits and vegetables per fully loaded mile, 1976

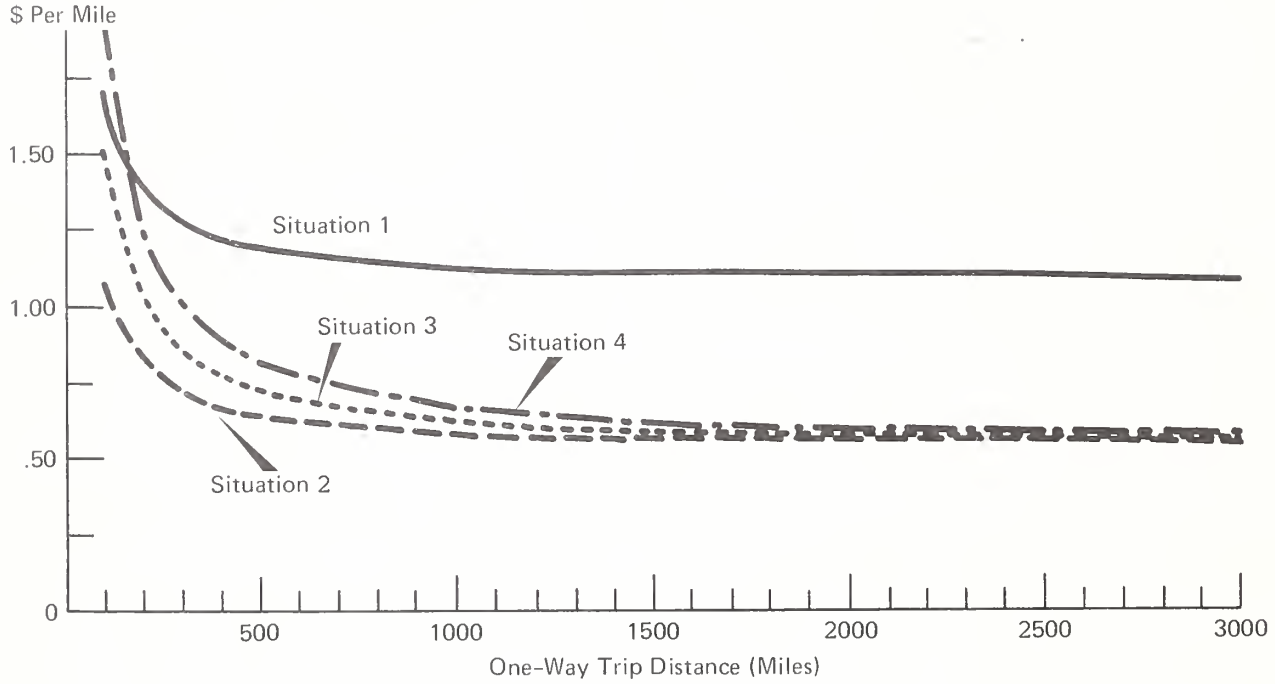
Operational situation 1/	One-way trip distance (miles)									
	100	200	300	400	500	1000	1500	2000	2500	3000
	Dollars per fully loaded mile									
1	1.773	1.286	1.277	1.209	1.226	1.146	1.097	1.087	1.071	1.091
2	1.026	.861	.678	.665	.634	.595	.577	.561	.552	.551
3	1.496	1.033	.853	.726	.773	.613	.596	.578	.566	.556
4	2.109	1.276	1.006	.811	.880	.641	.618	.593	.577	.568
5	2.109	1.615	1.400	1.369	1.311	1.226	1.123	1.104	1.096	1.098
6	1.664	1.055	.891	.771	.734	.642	.595	.579	.575	.567
7	1.999	1.224	1.044	.840	.798	.657	.611	.589	.585	.567
8	2.483	1.625	1.338	1.059	.903	.683	.634	.604	.599	.577
9	3.596	2.257	1.803	1.575	1.457	1.303	1.196	1.163	1.143	1.132
10	3.251	1.764	1.308	1.116	1.053	.705	.667	.630	.610	.595
11	3.251	2.033	1.308	1.116	1.053	.705	.672	.635	.614	.598
12	3.790	2.293	1.430	1.246	1.152	.732	.687	.641	.617	.607

1/ See table 7 for definitions.

Per mile cost for fully loaded miles illustrates the importance of additional pickups, deliveries, and backhaul delays to the cost and the rate charged. On a fully loaded mile basis, short trips are expensive to make and this must be reflected in the rates charged for these trips. For longer trips, cost per fully loaded mile is similar to that for total miles on trips with loaded backhauls. Thus, this analysis again illustrates the importance of loaded backhauls for longer trips. It also illustrates that having to wait for a loaded backhaul on short trips is very expensive, and, depending upon the rate charged for the loaded backhaul, may cost more than the revenue that it produces.

Cost functions, applying to fully loaded miles, were developed for six of the operational situations (table 15). The first value in each equation is the variable cost and applicable vehicle depreciation and driver cost generated by each fully loaded mile driven. The second value is the fixed cost and applicable vehicle depreciation and driver cost associated with the trip regardless of the number of miles driven. The functions are illustrated in figures 1 and 2.

Effects of Loaded Backhaul and Backhaul Delays on Estimated Cost Per Fully Loaded Mile (four operational situations)



See table 7 for definitions of operational situations.

FIGURE 1

Table 15--Cost functions for fully loaded miles, refrigerated trucks hauling fresh fruits and vegetables

Operational situation 1/	Equation 2/
1	$Y = 1.059 + \frac{64.59}{m}$
2	$Y = .533 + \frac{108.96}{m}$
3	$Y = .526 + \frac{195.71}{m}$
4	$Y = .518 + \frac{295.65}{m}$
5	$Y = 1.053 + \frac{119.64}{m}$
9	$Y = 1.052 + \frac{228.89}{m}$

1/ See table 7 for definitions.
2/ Y = dollars per fully loaded mile. m = fully loaded miles.

Figure 1 shows the effects of loaded backhaul and delays to obtain loaded backhaul on per mile cost. Figures 2 shows the effects of additional pickups and deliveries on per mile cost without backhauls.

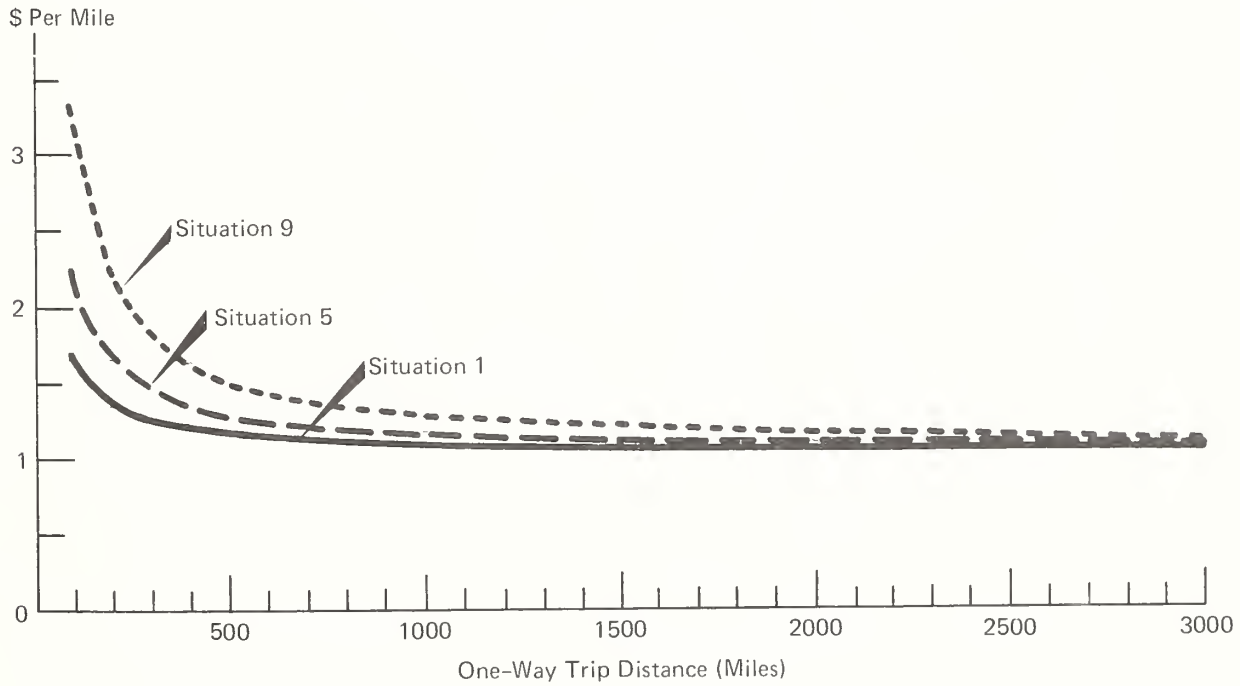
Table 16 illustrates the importance of total annual mileage in determining the cost per mile for operating trucks hauling fresh fruits and vegetables. The analysis was restricted to operational situation 6 and the 1,500-mile, one-way trip. Under these conditions, a truck operated 80,000 miles per year would have costs about 35 percent higher per mile than one operated 180,000 miles per year.

This analysis serves to show the importance of the different cost components that make up the total cost per mile. Table 17 shows what the four different cost components would be for each mileage category. This illustrates that fixed cost is the only component where savings can be generated by operating additional miles each year after certain minimum mileages have been reached for vehicle depreciation and for driver cost.

At 80,000 miles per year, the trucker would be achieving only about 44 percent of his driver-truck potential, whereas at 180,000 miles it would be approximately 100 percent.

These analyses indicate that vehicle utilization has an important bearing on the cost per mile for operating refrigerated trucks that haul fresh fruits and vegetables.

Effects of Additional Pickups and Deliveries on Estimated Cost Per Fully Loaded Mile for Operating A Refrigerated Truck Without Backhauls (three operational situations)



See table 7 for definitions of operational situations.

FIGURE 2

Table 16--Cost of operating a refrigerated truck for various total annual mileages under operational situation 6 and a 1,500-mile, one-way trip 1/

Annual miles per truck	Total mileage	Fully loaded mileage
	Dollars per mile	
80,000	.762	.800
90,000	.714	.750
100,000	.674	.708
110,000	.643	.675
120,000	.616	.647
130,000	.595	.625
140,000	.587	.616
150,000	.584	.613
160,000	.575	.604
170,000	.570	.599
180,000	.565	.593

1/ See table 7 for definition.

Table 17--Major cost components for operating a refrigerated truck under operational situation 6 and a 1,500-mile, one-way trip 1/

Annual miles per truck	Cost component				Total cost
	Fixed cost	Vehicle cost	Driver cost	Variable cost	
	Dollars per mile				
80,000	.174	.068	.295	.225	.762
90,000	.155	.067	.267	.225	.714
100,000	.139	.067	.243	.225	.674
110,000	.127	.067	.224	.225	.643
120,000	.116	.067	.208	.225	.616
130,000	.107	.067	.196	.225	.595
140,000	.099	.067	.196	.225	.587
150,000	.093	.067	.196	.225	.584
160,000	.087	.067	.196	.225	.575
170,000	.082	.067	.196	.225	.570
180,000	.077	.067	.196	.225	.565

1/ See table 7 for definition.

PRODUCT DENSITY AND RATES

The density of the product hauled is an important element in determining the rate per package a trucker must charge to cover his cost. Cost equations were developed for five loads with different product densities (table 18). These

equations were developed using operational situation 6 shown in table 7 and apply to fully loaded miles.

A trucker making a 3,000-mile, one-way trip using the cost equations in table 18 would have a total cost of approximately $3,323 for the entire trip. For a 31,500-pound payload, the cost would be $10.55 per 100 pounds for the initial haul compared to $8.01 per 100 pounds for a 41,500 pound payload.

Table 18--Cost equations for five loads with different product densities under operational situation 6 1/

Average payload	Equation 2/
Pounds	
31,500	Y = .3009 + .001708m
34,000	Y = .2798 + .001582m
36,500	Y = .2599 + .001474m
39,000	Y = .2446 + .001379m
41,500	Y = .2295 + .001296m

1/ See table 7 for definition.
2/ Y = Dollars per 100 pounds of payload. m = Fully loaded miles.

APPENDIX

The various cost figures in this report were developed through the use of the following equations. In all cases, the various cost components yielded total annual costs; these were then divided by total annual mileage to obtain the cost per mile shown in the various text tables. These equations can be used to develop costs for annual mileages not shown in the text or they can be used with different cost inputs. The equations are as follows:

1. Fixed cost per mile is: $F = \frac{F_1}{M}$

where:

F = Fixed cost per mile

F_1 = Total annual fixed cost per truck ($13,928)

M = Total annual mileage per truck

2. Depreciation cost per mile is: $D = \frac{D_1 + X_1 M_1 + X_2 M_2}{M}$

where:

D = Vehicle depreciation cost per mile

D_1 = Minimum vehicle depreciation per year for tractor and refrigerated trailer ($4,720)

X_1 = Depreciation cost per mile for tractors ($.047)

$M_1 = M - M_3$, where $M > M_3$, and

where:

M_3 = Minimum miles per year for tractors (65,000)

X_2 = Depreciation cost per mile for refrigerated trailers ($.02)

$M_2 = M - M_4$, where $M > M_4$, and

where:

M_4 = Minimum miles per year for refrigerated trailers (85,000)

3. Driver cost per mile for one driver is:

$$C_1 = \frac{S_1 + X_3 S_m + X_4 S_n + X_5 S_1 + X_6 S_1 + X_7 d}{M}$$

where:

C_1 = Cost per mile for one driver

$S_1 = S + R_1 M_5$

where:

S = Minimum yearly salary per driver ($9,000)

R_1 = Rate per mile one driver ($.12)

$M_5 = M - M_6$, where $M > M_6$, and

where:

M_6 = Yearly mileage required to achieve minimum yearly salary (75,000)

X_3 = Social Security rate (5.85% of wages)

$S_m = S_1$, where $S_1 \leq S_3$, and

where:

S_3 = Maximum wages on which Social Security is paid ($15,300)

X_4 = Unemployment compensation insurance rate (2.6% of wages)

S_n = Maximum wages on which unemployment insurance is paid ($4,200)

X_5 = Workmen's compensation insurance rate (7.96% of wages)

X_6 = Health and welfare rate (2.4% of wages)

X_7 = Driver subsistence rate per trip-day ($10.00)

d = Number of trip-days per year

4. Driver cost per mile for a two-driver team is:

$$C_2 = \frac{S_2 + X_3\ 2S_m + X_4\ 2S_n + X_5\ S_2 + X_6\ S_2 + 2X_7 d}{M}$$

where:

C_2 = Cost per mile for two-driver team

$S_2 = 2S + R_2 M_7$

where:

R_2 = Rate per mile for two-driver team ($.14)

$M_7 = M - M_8$, where $M > M_8$, and

where:

M_8 = Yearly mileage required to achieve minimum salaries for two drivers (128,572 miles)

5. Direct variable cost per mile is: Y = $.225

6. Total cost per mile is:

$T_1 = F + D + C_1 + Y$ = Total cost per mile using one driver

$T_2 = F + D + C_2 + Y$ = Total cost per mile using a two-driver team

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SUMMARY

Estimated costs per mile for operating refrigerated trucks to haul fresh fruits and vegetables are developed for various trip lengths, operating situations, and different levels of driver-truck utilization. These costs are obtained using a synthetic cost analysis of model 10-truck firms with cost components obtained in 1976 from nine firms operating refrigerated trucks and other sources.

Fixed costs are those items that a trucker would have regardless of the number of trips. Vehicle depreciation and driver costs are analyzed as separate categories because they have attributes of both fixed and variable costs. Variable costs are those items directly related to the number of miles driven.

Costs per mile are developed for two basic types of situations. One is for trips of different lengths and operating conditions and the other for the number of miles a truck is operated each year. Differences in cost per mile are due primarily to the level of driver-truck utilization as measured by total annual truck mileage.

Per mile costs are developed for fully loaded miles and for total trip miles. In general, the costs per mile decrease as the length of trip increases. Loaded backhaul increases the per mile costs considerably for shorter trips but only slightly for the longer trips. Multiple pickups and deliveries have the same type of effect on per mile costs as loaded backhauls.

Product density is very important in determining the level of hundredweight rates. A payload of 31,500 pounds requires rates about 32 percent higher than a 41,500-pound payload to cover cost.

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